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Comparison of indoor radon and thoron concentrations in the urban and rural dwellings of Chhattisgarh state of India

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Abstract

In the frame of nationwide radon/thoron monitoring program, indoor radon/thoron and their progeny concentrations have been estimated for 210 dwellings situated in 8 towns (urban) and 9 villages (rural) of Chhattisgarh state of India. The measurement has been made on quarterly integrating cycle for one full year in each dwelling. Twin chamber dosimeter cup with LR-115 Type-II Solid State Nuclear Track Detector was used for the measurement of indoor radon/thoron concentration. The results show that the geometric mean of indoor thoron concentration in urban dwellings varies from 11.57 to 25.88 $\mathrm{Bq\,m^{-3}}$ with an overall geometric mean value of 16.65 $\mathrm{Bq\,m^{-3}}$, while in rural dwellings it varies from 12.50 to 30.08 $\mathrm{Bq\,m^{-3}}$ with an overall geometric mean value of 19.00 $\mathrm{Bq\,m^{-3}}$. The potential alpha energy concentration (PAEC) levels of thoron in the urban and rural dwellings are found to be 2.58 and 4.57 mWL, respectively. Similarly, the geometric mean of indoor radon concentrations in urban dwellings is found to vary from 20.20 to 30.13 $\mathrm{Bq\,m^{-3}}$ with an overall geometric mean value of 25.28 $\mathrm{Bq\,m^{-3}}$, while in rural dwellings it varies from 15.50 to 36.05 $\mathrm{Bq\,m^{-3}}$ with an overall geometric mean value of 27.32 $\mathrm{Bq\,m^{-3}}$. The PAEC levels of radon in the urban and rural dwellings are found to be 1.50 and 1.87 mWL, respectively. The dose contribution of thoron and progeny in total inhalation dose has been found to be more than 20% in all the surveyed places that show the necessity to pay attention to the presence of thoron and progeny from public health point of view.

Keywords: Indoor thoron; Radon; Potential alpha energy concentration; Solid state nuclear track detector; Inhalation dose

1. Introduction

The health risk due to the presence of thoron is usually neglected because of its relatively low concentration inside the dwellings. However, the recent studies performed in some parts of India show that the dose due to thoron and progeny is about half of that due to radon, and its progeny and contribution of inhalation dose rate due to thoron and its progeny is seen to be approximately 17% of the total inhalation dose rate (BARC Report, 2003). Only in a small number of countries, indoor thoron monitoring activities have been conducted (Doi et al., 1994; Guo et al., 2001; Virk and Sharma, 2002; Martinez et al., 2004). In the present study, indoor thoron and radon concentrations have been measured in various dwellings of urban and rural sites of Chhattisgarh state of India. The main aim of the present study is to compare indoor radon and thoron concentrations in the urban and rural dwellings of Chhattisgarh state of India. In general, the dwellings of urban areas are made of cement, concrete, steel beam and bricks; however, rural dwellings are mostly made of mud. This study also aims at finding out the reasonably reliable values of thoron and radon concentrations and knowing the contribution of thoron and its progeny in total inhalation dose.

2. Experimental method

Fig. 1 shows the locations of towns and villages in the map where thoron/radon measurements were carried out. The locations of towns and villages were selected in such a way to cover

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Fig. 1. Map of Chhattisgarh state with locations of towns and villages where thoron/radon measurements were carried out.

major and distant regions of the state. The measurement has been made on quarterly integrating cycle, for one full year in each dwelling. LR-115 type-II solid state nuclear track detector was used as a detector. Detectors were loaded in a twin chamber dosimeter, developed and calibrated at Bhabha Atomic Research Centre, Mumbai. The cup-shaped dosimeter has three modes of exposure, i.e. bare, filter and sandwiched membrane mode. The bare mode records tracks due to radon, thoron and their progeny. The filter mode gives the concentration of radon and thoron, whereas the sandwiched membrane mode gives the concentration of radon only. The cup dosimeters with detectors were suspended at about 20 cm away from the wall and about 2 m above the surface of bedrooms of the dwelling for 90 days, during which time the alpha particles originating from radon, thoron and their progeny form tracks on it. Exposed films were chemically etched in 2.5 N NaOH solution at 60 °C with a constant temperature water bath for 60 min with mild stirring. The etched films were washed, dried and then stripped off from the polyester base, and then track densities (tracks cm^{-2}) were counted using pre-calibrated spark counter, supplied by Polltech Instrument, Mumbai. Thoron and radon concentrations were estimated using the calibration factor obtained from the calibration set-up available at the Environmental Assessment Division Laboratory, Bhabha Atomic Research Centre, Mumbai. The details of standard calibration methods are described elsewhere (Ramachandran et al., 1990; Eappen, 1994; Ramachandran et al., 1995; Srivastava et al., 1995). Radon and thoron progeny concentrations were calculated using the track density on detectors exposed in bare mode along with a filter and sandwiched mode. Inhalation dose was calculated from the gas concentration of radon and thoron with the corresponding value of equilibrium factors.

3. Results and discussion

The annual geometric means of indoor thoron and radon concentrations along with their respective geometric standard deviations in the dwellings of urban and rural sites of Chhattisgarh state are listed in Tables 1 and 2, respectively. The geometric mean of indoor thoron concentrations in urban dwellings has been found to vary from 11.57 to 25.88 Bq m^{-3} with an overall geometric mean value of 16.65 Bq m^{-3}, while in rural dwellings it varies from 12.50 to 30.08 Bq m^{-3} with an overall geometric mean value of 19.00 Bq m^{-3}. The indoor radon concentrations in the urban dwellings have been found to vary from 20.20 to 30.31 Bq m^{-3}, while in rural dwellings it varies from 15.50 to 36.05 Bq m^{-3}. Considering the source of error associated with etch track detector, the variations in indoor thoron and radon concentrations in most of the places are not significant. This is due to the fact that, although the geological background is slightly different in different parts of the state, the climate and lifestyle of the inhabitants are almost the same as in Chhattisgarh state. One of the reasons for a relatively low indoor radon/thoron level is that the benign climate in this region encourages the opening of the window for most of the year. Similarly, in most of the places, limestone is found; this is known for low content of uranium (Menon et al., 1987). The mean indoor thoron levels were found to be relatively higher in